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Proceedings of the Maritimes Regional Peer Review of the Basking Shark Assessment

22-23 January 2008
Bedford Institute of Oceanography

Tana Worcester, Chairperson and Editor

Fisheries and Oceans Canada
Bedford Institute of Oceanography
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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

The Maritimes regional peer review of the assessment of basking shark was held in January 2008. Participation in this meeting included Fisheries and Oceans Canada (DFO), non-DFO scientists, and non-governmental organizations (NGOs). Others were invited but did not attend the meeting. The results of this meeting are expected to be considered in the assessment of basking shark by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Compte rendu de l'examen par les pairs de la région des Maritimes de l'évaluation du pèlerin

SOMMAIRE

L'examen par les pairs de la région des Maritimes de l'évaluation du pèlerin a été tenu en janvier 2008. Les participants à cette réunion comprenaient des représentants de Pêches et Océans Canada et d'organisations non gouvernementales ainsi que des scientifiques de l'extérieur de Pêches et Océans Canada. D'autres personnes ont été invitées, mais elles n'ont pas assisté à la réunion. Les résultats de cette réunion devraient être pris en compte dans l'évaluation du pèlerin par le Comité sur la situation des espèces en péril au Canada (COSEPAC).

INTRODUCTION

After welcoming participants (Appendix 1) and doing a round of introductions, the chair (T. Worcester) provided a brief introduction to the meeting. She noted that this was a science peer-review meeting, which means that it would be focussed on the development of science information rather than on the management implications of that information. While everyone was invited to participate fully in the discussion and contribute knowledge to the process, the intent was to deliver a scientifically defensible product. The external peer reviewers were introduced, including:

- Robert Kenney (University of Rhode Island),
- Scott Wallace (David Suzuki Foundation),
- Howard Powles (COSEWIC),
- Kurtis Trzcinski (DFO Maritimes), and
- Jamie Gibson (DFO Maritimes).

It was noted that Basking Shark was being assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and information developed through this meeting would contribute towards their review. The Terms of Reference for the meeting (Appendix 2) were reviewed, including the objectives of this meeting, which were:

- To comment on the accuracy and representativeness of observer and Basking Shark sighting information in the Right Whale Database that has become available since the compilation of the COSEWIC status report.
- To prepare estimates of total annual discards by gear sector in relation to sustainability.
- To review life history models of basking shark, their assumptions, parameter estimates, and outputs in the terms of precision and bias.

The Agenda (Appendix 3) was reviewed and nothing further was added.

STATUS OF BASKING SHARK

HABITAT AND DISTRIBUTION

Information was provided by S. Campana on the habitat preferences and distribution of Basking Shark in Canada with a focus on water temperature, which seems to define their distribution. There appear to be a problem with misidentification of Basking Shark as Greenland Shark in the northern records. Some effort has been spent trying to remove misidentifications, but it may be more effective to exclude basking shark records north of 50° as it is unlikely that Basking Shark would be seen this far north. Records of Basking Shark along the shelf edge may also be a result of misidentification.

Discussion

There was some discussion on the source of data used in the analysis, specifically whether American data was used, the 2007 DFO survey conducted by Jack Lawson, and surveys conducted in the early 1980s. There was discussion about the observer program as a source of information on Basking Shark. It was noted that the sharks are not generally brought on board and that training related to shark identification is not a focus of the program. There were 415 total records from the Newfoundland and Labrador (NL) observer program, and 375 of these were suspect. Some paper records exist until 1993 which do indicate a length measured if a

shark was brought on board, but most do not mention whether or not the shark was brought on board. It was expected that misidentification of Basking Sharks might be reduced if they were inspected on board a vessel.

ABUNDAUNCE INDICES

Information was provided by S. Campana on potential abundance indices. An analysis of Catch Per Unit Effort (CPUE, or sightings per unit effort) did not provide useful results. Results from visual surveys were adjusted for factors such as visibility relative to right whales (e.g., size bias), proportion of time at surface, recording bias, and relative visibility from air or ship to produce a rough estimate of 4,200 Basking Sharks. Results from aerial surveys provided an estimate of 2,700 Basking Sharks; however, the assumed proportion of time spent at the surface (36%) may need to be revised.

Discussion

There was some discussion on the use of zeros in the analysis and whether it would be possible to produce a map of observation effort. There was also a discussion on the possible explanations for movement of Basking Sharks out of the area in the late 1990s, possibly related to the North Atlantic Oscillation. It was asked whether future aerial surveys were planned. The response was that international surveys were planned for every 10 years but that countries are on their own to raise money for these surveys. There were discussions on the visibility of Basking Sharks relative to Right Whales. It was suggested that, if there was enough data, it might be possible to work out a detection function. There was also discussion on reporting bias. Some concern was expressed with providing an absolute estimate of Basking Shark numbers, and it was asked whether it would be possible to provide an index with just the aerial survey data. However, very few aerial surveys were done in the Bay of Fundy, and none were line transect surveys. The problems with a sightings per unit effort (SPUE) index, particularly related to movement in and out of the area, were discussed in more detail. Canadian sightings data were compared to nearby US data, but decreases in one area did not appear to result in increases in the adjacent area. It was suggested that no one index should be used. Rather a number of different indices should be considered together. Also, it was asked whether the information available was sufficient to provide an upper or lower bound for an abundance estimate. It was noted that, every year, there are reports in Emerald Basin of groups of 4-10 Basking Sharks circling and probably mating. In the Bay of Fundy, groups are seen. Off Martha's vineyard, groups of 60 individuals are seen. In the Pacific, aggregations of hundreds of individuals are seen.

Conclusion

The conclusion of this discussion was that there were likely several thousand Basking Sharks (in the range of 6,000 ± 2,000) in the Bay of Fundy plus Scotian Shelf.

LIFE-HISTORY INFORMATION

Information was provided by S. Campana on aging and growth information for Basking Shark. He noted that otilith bands are not considered to be representative of ages, and the bands are likely over-representing age by 7-8 years. The Pauly curve is considered to be the best representation of growth. Understanding of the gestation period estimation is limited.

Discussion

The age at maturity was discussed, as was the length of pups (1.5-2 m) and whether there is a reproductive down time for Basking Shark. It was suggested that the pup mortality should be centered around 2. There was some discussion about small Basking Shark – whether they are fished under 3 m and whether they are seen very often. In the UK, there is an active sightings network and Basking Shark less than 3 m are rarely seen. A summary of known life-history information was reviewed, the results of which are presented in Table 1.

Table 1. Life-history parameters for Basking Shark in the Maritimes Region.

Parameter	Value (range)	Source
Gestation period	3 years (2.5-3.5 years)	Parker and Stott (1965), Pauly (2002), CITES (2002)
Length at maturity: (males) (females)	 4.6 - 6.1 m - no info on females	Bigelow and Schroeder (1953)
Longevity	50 years 8 years – definitely wrong 33 growth bands 44 growth bands (7-8 years)	Pauly (2002) Parker and Stott (1965) Natanson et al. (unpub) Campana et al. (unpub)
Age at maturity (males) (females)	 12 - 16 years 16 - 20 years (18 years)	CITES (2002)
Productivity (r_{msy})	0.013-0.023	Smith et al. (1998)
Natural mortality (M)	0.068 0.091	Pauly (2002) CITES (2002)
Generation time	33 years 22 years	Wallace et al. (2005) CITES (2002)
Litter number	3 pups per female 6 embryos per female	CITES (2002) Based on one observation

BYCATCH ESTIMATES

Presentation Highlights

Information on bycatch of Basking Sharks is available from the following sources:

Foreign

- International Observer Program (1978-2007)
- 100% observer coverage on foreign vessels since 1987
- Basking Shark is caught primarily in redfish and silver hake fisheries

- Catch peaked in 1980-1990 at approximately 100 mt/year, with only 1 mt/year since 2000

Domestic

- <5% observer coverage on domestic vessels
- Landings recorded in ZIF and MARFIS databases
- Catches peaked in 1980-1990s, with an average of 10 mt/year for all fleets
- Basking Shark are caught mostly in redfish and groundfish trawls (scaled to 122 mt/year) on the Scotian Shelf
- Weight peaked at 665 mt in 1990 and 154 mt/year since 1986
- Numbers were 309 basking sharks per year since 1986 (revised)

The methodology for estimating Basking Shark bycatch was to take the ratio between observed basking shark discards and the observed target species catch. No one caught large numbers of Basking Shark, but the weights were quite large. The mean weight in NL and the Scotian Shelf were quite similar. Given skew, using the median weight might be better. If the median weight is used, the Scotian Shelf was 1,000 mt and NL was 500 mt, but if northern NL is removed, the median weight would be 1,000 mt. Results from northern NL were quite high and may have been Greenland Shark rather than Basking Shark.

Discussion

There was discussion on observer protocols and practice. For example, it was asked whether observers were estimating weight only or length. The response was that a few recorded length, but most recorded weight. The numbers of sharks caught were not often recorded. Standard procedure is not to bring them on board. The trawl fisheries can bring them up on deck, but even the DFO Research Vessel (RV) surveys do not record the length. Skippers sometimes record information when the observer is sleeping. Some very small sharks were recorded. It is unclear on whether these might have been newborn Basking Sharks or Greenland Sharks.

There was some discussion about how the foreign silver hake fishery could have caught so many more fish than the domestic fishery, and whether this was related to different fishing techniques, gear, seasons, etc. It was agreed that one uncertainty of this assessment was related to the low observer coverage on the domestic fleet. It was noted that foreign vessels could have been keeping sharks. It was also suggested that observers on the foreign fleet may be over-estimating basking shark (due to incorrect identification and mix-up with Greenland shark). It was asked whether it would be possible to estimate the different in being able to capture a rare event (like shark capture) with different levels of observer coverage.

It was asked whether basking shark were ever captured in the shrimp fishery. It was asked whether the Norwegians have reported basking shark bycatch in their shrimp fishery. This could be checked.

It was noted that, in simulations of low population size, the "index of distribution" decline is over-estimated when the density of a population drops. It is not clear whether this applies to abundance (not peer reviewed).

Suggestions

- Discard estimates could be reported as totals by decade or averaged.
- The uncertainties in the data should be described:
    - 5% coverage
    - Scotian Shelf edge issue not addressed

  - Estimated weights are not real weights
  - Mortality rate is not known (some are alive when they go back in the water)
  - Not all fisheries are accounted for (e.g., inshore fisheries – cod gillnet and cod trap).
- An estimate could be provided of the possible annual deaths (range)
- Table 5 corrected is the best guess.
- A loess smoothed line through discard numbers could also be used in the model, but providing the mean and the range is simpler. Both can be included.
- It should also be noted that there have been changes in the fisheries with a downward trend in bycatch. There is a lot less gear in the water since the 1980s. However, it is hard to quantify effort.

NEWFOUNDLAND REGIONAL DATA

Presenter: Mark Simpson

Presentation Highlights

There have been 3 basking shark captures in NL surveys since the stratified spring survey began in 1971. There was 1 in 2J, 1 in 3K and 1 in 3N. In the NL marine mammal aerial surveys (J. Lawson), there were 28 sightings of 31 basking sharks from 1980-2007. From the 2007 survey results, there were 5 sightings in NL waters - 1 off the northeast and 4 off the south coast. These could be added to the figures. There should be no overlap with the Maritimes data.

Observer calculations were redone with "observed basking shark" divided by "observed catch of directed species" from 1995 forward. In the 1979-2006 period, there were 425 records of basking shark. However, investigation of the paper records since 1993 indicated some improper coding, suspect identification, and estimated catches. There was lots of variation in the estimated weights. So, in the revised estimates, weights less than 150 kg were removed (though there was likely some invalid weight data for valid records). Basking shark records from 2H and 2J (south) due to unlikely timing (Nov-Mar). Another 17 records were removed from an observer who said later that he thought they were Greenland sharks. There are now 37 records now for the time period. There were larger catches in 1995 and 2002. Only Canadian landings were considered.

Discussion

It would be interesting to compare catches in the RV survey for Greenland sharks.

It was asked whether there was any corresponding temperature data with the basking shark records. The response was that there was not.

It was asked whether determination of the length / weight relationship included data on Greenland sharks. The response was that it did not, but it did include data from Norway and pelagic longline datasheets (extras).

In general, the methods used were consistent with what Maritimes had done. This could be considered a minimum estimate.

It was asked whether there was data from the foreign shrimp fishery (3M). This fishery occurs outside Canadian waters, which is not COSEWIC's jurisdiction. However, 3 sharks were caught in Canadian shrimp fishery (1990, 1999, 2005).

US DATA

Basking shark were reported per 1000 km of trackline surveyed in sea states of less than 4, with at least one observer on watch.

All aerial surveys were flown on good weather days to observe basking sharks.

The southeast US and southern Gulf of Maine show an increasing trend (low r2). Effort has varied over time. In the Gulf of Maine, effort was high in the 1970s, low in the middle and then high again. In the southeast US, effort was low to the mid-1990s and then it stepped up.

POPULATION MODELING

Decline Rates and Extinction Risks for Basking Shark in the NW Atlantic

Presenter: Peter Shelton

Presentation Highlights

The starting point for the analysis was the status report in 2007. It is unclear why CITES used r_{msy} when the assumptions do not hold. It is possible to do the modelling, but it is assumed that there is no density dependence. It should be possible to get the same answer with the two approaches mentioned previously. The intrinsic rate of increase is meaningless, but F_{crit} can be determined.

This population teeters on the edge of extinction. Pup production needs to be decreased by female mortality (if females die when they are pregnant), as pregnant females are also vulnerable to exploitation. Since pups do not seem to appear in incidental mortality (bycatch), an age refuge before the age three may be appropriate.

Need population decline rates for COSEWIC. Ncrit and Fcrit are a good starting point.

Discussion

It was suggested that a pupping rate of 6 pups should be used instead of 3. Once basking shark are pregnant, they cannot get pregnant again for three years.

It was asked whether the rate of increase was an annual rate of increase. The response was that it was an instantaneous rate, but the instantaneous rate is approximately equivalent to the annual rate at these low population levels.

It was suggested that 7% seems like an appropriate growth rate for a species with a 50 year lifespan. It was noted that Right whales have 50-60 year lifespan, with only 1 pup each, but can grow at 7-8%. This was considered a good comparison.

It was asked whether there should be changes in mortality rates with age, as adults mortality rates might go up as they get older (do not normally worry about this for fish).

If M is varied from 0.091 to 0.06, there is a big difference in the result. There is also a different if you use 3 every 3 years as compared to 2 every year.

It was asked whether the temperatures were appropriate (10 degrees). Temperature could be reduced to 6-7 degrees.

Variability could be added to the age at maturity

The 2007 abundance estimates were 5,000, 11,000, and 20,000). This could be treated as range from 5,000-20,000.

From the revised table of discards, the average annual discards are 162 basking shark. It was suggested that the annual values be used rather than a loess smoothed line.

It was asked whether there was a desire to calculate N_{crit} and F_{crit} only or to try to determine the decline rate. It was suggested that N_{crit} should be compared to removals.

Output will be random draw of the population size, random draw from life-history values, etc. and will work out trajectory over time. The starting population sizes and range of declines can be summarised.

Table 2. Life history characteristics from the literature.

Parameter	Value (range)	Source
Productivity (r_{msy})	0.013-0.023 <0.05-0.15	Smith et al. (1998) Musick et al. (2002)
Natural mortality (M)	0.068 0.091 0.060 (0.04-0.09) 0.03-0.09	Pauly (2002) CITES (2002) FishBase (2007) For modeling purposes
Gestation period	3	
Age at maturity	16-20 years	
Litter size	2-4	

Table 3. Agreed to model input.

Model Function	Model Input
Natural mortality (M)	0.068±0.01
Gestation period	3 (2-4) – fixed
Age at maturity	16-20 years
Litter size	6 (5-7) – fixed in year
Pup mortality multiplier	2 (±0.5)
Longevity	50 years
Productivity (r)	0.37, 0.49, 0.51 (Jamie)

Table 4. Model outputs.

Parameter	Value (range)	Source
Productivity (r_{msy})	0.00049 0.02889 *likely around 0.3	Simulation model (no density) Using FishBase values From modeling
F_{crit}	0.00059 0.03473	Simulation model (no density) Using FishBase values
N_{crit}	89,573 (50 deaths per year) 179,146 (100 deaths per year) 1,511 (50 deaths per year) 3.022 (100 deaths per year)	Simulation model (no density) Using FishBase values

Combing Abundance Indices

From the 2007 NLFD survey, 5 shark observed. With scaling, this gives 201 basking sharks (93% CV: 42-970). With an assumption of 36% at the surface, this gives 558.

There have been changes to the SS and Gulf survey. They are using a new strip width, which gives 6,160 basking shark for the SS and Gulf.

The Bay of Fundy population has already been discussed.

Combining these numbers gives a total abundance of:

- 6,160 + 558 + 4,200 = 10,918 (need to include range).

However, this does not take into account the male:female ratio at the surface.

- There were 3 female and 2 that were not sexed.

The difference between 5,000 and 10,000 animals could be the difference between a sustainable population and one that is not. If there are 20,000 animals, there may be density dependence effects.

REVISIONS

Presenter: Peter Shelton and Jamie Gibson

If P. Shelton uses 0,0,6 pregnancy, he gets an r of 0.54, which is closer to J. Gibson and S. Campana's results.

J. Gibson used a Monte Carlo approach, input parameters from yesterday, and did projections using annual discard estimates, doubling actual discards (to account for other sources of mortality), and average discards. This resulted in lots of variability. Most runs gave increasing populations, with a small proportion below zero. Using average removals, get smooth trajectories and fewer runs showing decline. Using double the removals, see much greater probably of decline. Some sensitivities have not been explored (e.g., changes in starting abundance). This result is relatively positive, but care should be taken in interpretation.

With an M of 0.9, get greater indication of decline. If you do this, r is reduced.

Discussion

It was asked what population size would be needed to get a decline. The response was an N_{crit} of 3,300.

It was asked that the most important variables were. The response was starting population size was important, though sensitivity analysis was not done to test this.

It was asked what a lower M do (0.9 instead of 0.98).

It was suggested that there is no strong evidence of decline and that maybe this species is not in trouble. It may be possible to say that, given the current understanding of the current population size, we believe that the population is stable or increasing.

Suggested alternative wording was that a population of less than 3,000 would be a concern.

It was suggested that a run with a lower population bound of 3,000 and a natural mortality of 0.068 be done.

There was some discussion of generating population estimates from genetic analysis. It was suggested that this may not be appropriate.

A source of uncertainty is the proportion of bycatch on the Scotian Shelf that was misidentified as Greenland shark.

Also, US bycatch is not known. A suggestion was made to look at US bycatch records and abundance estimates. The US did some surveys on the Scotian Shelf (2-3 surveys). The Bay of Fundy was done (aerial and shipboard surveys) last year, 2004, and possibly 2002. They went as far as the mouth of the Saint Lawrence. This would be useful information for a Recovery Potential Assessment.

It was noted that an exponential model is not appropriate unless the population is assumed to be close to zero. Other vulnerability in putting forward an exponential model were discussed.

There was further discussion of the importance of density dependence in sharks. It was suggested that porbeagle and spiny dogfish data indicate that carrying capacity can go close to infinity. Density dependence is not just about competition for food. There can also be behavioural modifications. Historical carrying capacity may not be meaningful when environmental characteristics changing faster than population.

Another source of uncertainty is about the life-history characteristics of basking sharks.

The probably that decline has happened from 1987 to 2007 is low.

It was agreed that the analysis has been taken as far as possible with the available data.

RESEARCH RECOMMENDATIONS

OBSERVER PROTOCOL

Observers currently measure weight, but it was suggested that they should estimate length and record the number caught.

SURVEYS AND MONITORING

There was support to conduct another aerial survey in 5-10 years, including the Bay of Fundy.

Surveys to determine the location of newborn sharks would be useful for modelling.

US DATA (ABUNDANCE VERSUS BYCATCH)

It was suggested that there be further investigation of US observer records, and discussions with observers about bycatch rates.

AGING

It was suggested that more bomb dating should be done to confirm aging.

CONCLUDING REMARKS

MODELING REVISIONS

It was recommended that, if modeling revisions resulted in more than a 50% reduction in estimated abundance (significant), the meeting would be recalled through a teleconference.

RESEARCH DOCUMENTS

It was suggested that only a single Research Documents should be produced.

SCIENCE ADVISORY REPORT

The final Science Advisory Report would be circulated prior to publication.

THANKS

Participants were thanked for their active participation in and contributions to this meeting.

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APPENDIX 1: LIST OF PARTICIPANTS

Name	Affiliation
Boudreau, Cyril	NS Fisheries and Aquaculture
Campana, Steve	DFO Maritimes / PED
Ford, Jennifer	Ecology Action Centre (EAC)
Gibson, Jamie	DFO Maritimes / PED
Kenney, Robert	University of Rhode Island
Kulka, Dave	DFO Newfoundland / O&E
Powles, Howard	University of Ottawa, School of Mgmt.
Shelton, Peter	DFO Newfoundland
Simpson, Mark R.	DFO Newfoundland / SARA
Smedbol, Kent	DFO Maritimes / SABS
Trzcinski, Kurtis	DFO Maritimes / PED
Wallace, Scott	David Suzuki Foundation
Worcester, Tana (Chair)	DFO Maritimes / CSA

APPENDIX 2: TERMS OF REFERENCE

Review of Analyses on Atlantic Basking Shark (*Cetorhinus maximus*)
Maritimes Region Science Advisory Process

The Gully Boardroom
Bedford Institute of Oceanography
Dartmouth, Nova Scotia

26 - 27 September 2007 (POSTPONED)

POSTPONED – 22-23 JANUARY 2008

TERMS OF REFERENCE

Context

The implementation of the federal Species at Risk Act (SARA), proclaimed in June 2003, begins with an assessment of a species' risk of extinction by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). An assessment initiates the regulatory process whereby the competent Minister must decide whether or not to accept COSEWIC's assessment and add a species to Schedule 1 of SARA, which would result in legal protection for the species under the Act. DFO is to provide COSEWIC with the best information available to ensure that an accurate assessment of the status of a species can be undertaken.

A status report for basking shark was prepared and presented to COSEWIC at its April 2007 meeting. It was agreed that final consideration of the status report would be deferred until additional qualitative analyses that it identified as useful were undertaken. The current meeting is to review these new analyses. COSEWIC has tentatively planned to reconsider the basking shark status report in November 2007.

Objectives

- To comment on the accuracy and representativeness of observer and basking sharking sighting information in the Right Whale Database that has become available since the compilation of the COSEWIC status report.
- To prepare estimates of total annual discards by gear sector in relation to sustainability.
- To review life history models of basking shark, their assumptions, parameter estimates, and outputs in the terms of precision and bias.

Outputs

- CSAS proceedings recording the discussion .
- CSAS research document of the technical details.

Participation

DFO Maritimes and Newfoundland Science, Fisheries & Aquaculture Management, and Oceans

COSEWIC chairs and authors

APCFNC Secretariat

NS and NB Provincial representatives

Fishing industry, specifically silver hake fishery

NGOs (WWF and EAC)

External experts

APPENDIX 3: AGENDA

Review of Analyses on Atlantic Basking Shark (*Cetorhinus maximus*)
Maritimes Region Science Advisory Process

The Gully Boardroom
Bedford Institute of Oceanography
Dartmouth, Nova Scotia

22 - 23 January 2008

DRAFT AGENDA[1]

22 January 2008 – Tuesday

0900 – 0915	Welcome, Introduction, and Review of Agenda
0915 – 1200	Review of basking shark sighting information and observer data Review estimates of bycatch Review of life history models
1200 – 1300	Lunch
1300 – 1700	Completion of working paper reviews
	Discussions

23 January 2008 – Wednesday

0900 – 1200	Review of Conclusions
1200 – 1300	Lunch
1300 – 1700	Review of Conclusions (if required)
17:00	Adjournment

[1] Health breaks will be provided mid-morning and mid-afternoon